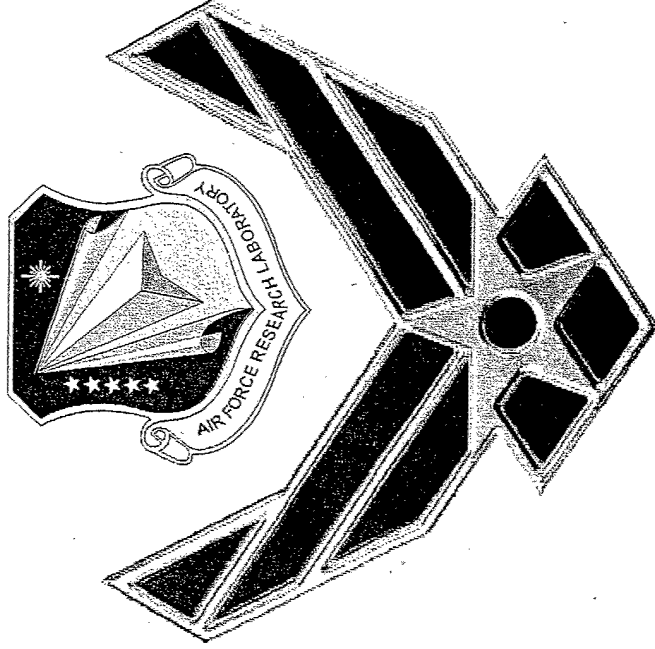


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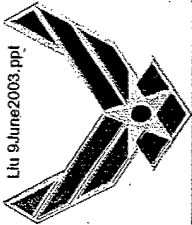
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The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion



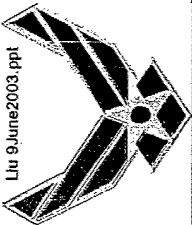
C. T. Liu
AFRL/PRSM
Edwards AFB, CA



Objectives:

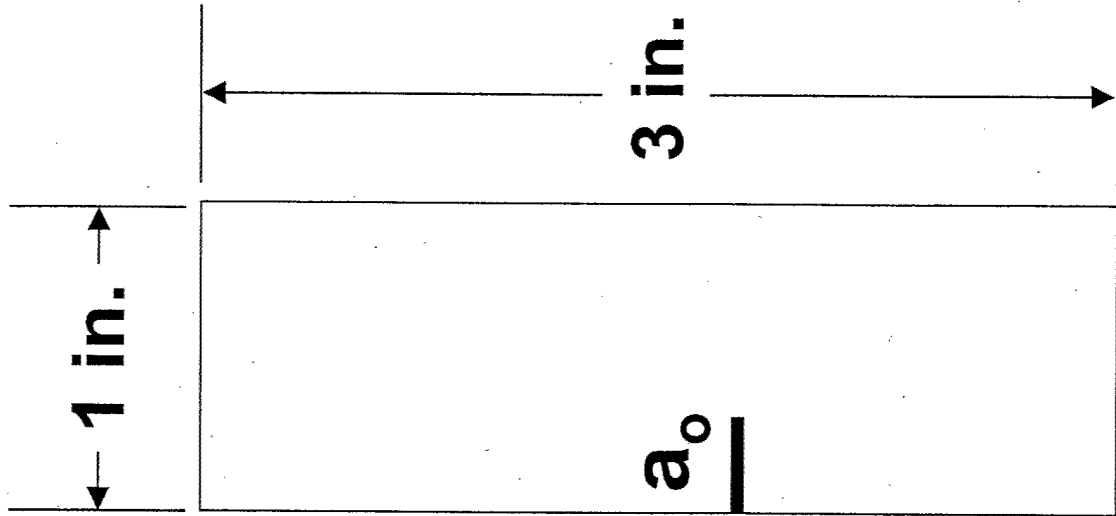


- **Determine the Inherent Critical Initial Crack Size in a Particulate Composite Material for Developing an Inspection Criterion.**
- **Determine the Statistical Distribution Function of the Inherent Critical Crack Size.**

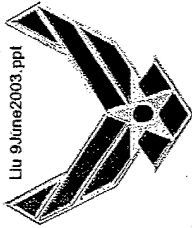


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Specimen Geometry



$$\begin{aligned} a_o &= 0.0 \text{ in.} \\ &= 0.1 \text{ in.} \\ &= 0.2 \text{ in.} \\ &= 0.3 \text{ in.} \end{aligned}$$



Crack Growth Equations

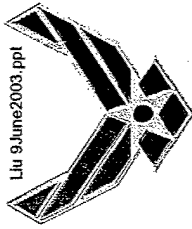


$$K_I = \sigma (\pi a)^{1/2} f(a/w)$$

$$f(a/w) = 0.77722(a/w)^3 + 0.9253(a/w)^2 + 1.095(a/w) + 1.005$$

$$K_{IC} = \sigma_c (\pi a_c)^{1/2} f(a_c/w)$$

$$da/dt = Q K_I^m$$



Statistical Distribution Functions



$$F_X(x) = \Phi\left(\frac{x - u}{\sigma}\right)$$

Normal Distribution

$$F_X(x) = \Phi\left(\frac{\ln x - u^*}{\sigma^*}\right)$$

Lognormal Distribution

$$F_X(x) = 1 - \exp\left[-(x/\beta)^\alpha\right]$$

Two-Parameter Weibull Distribution

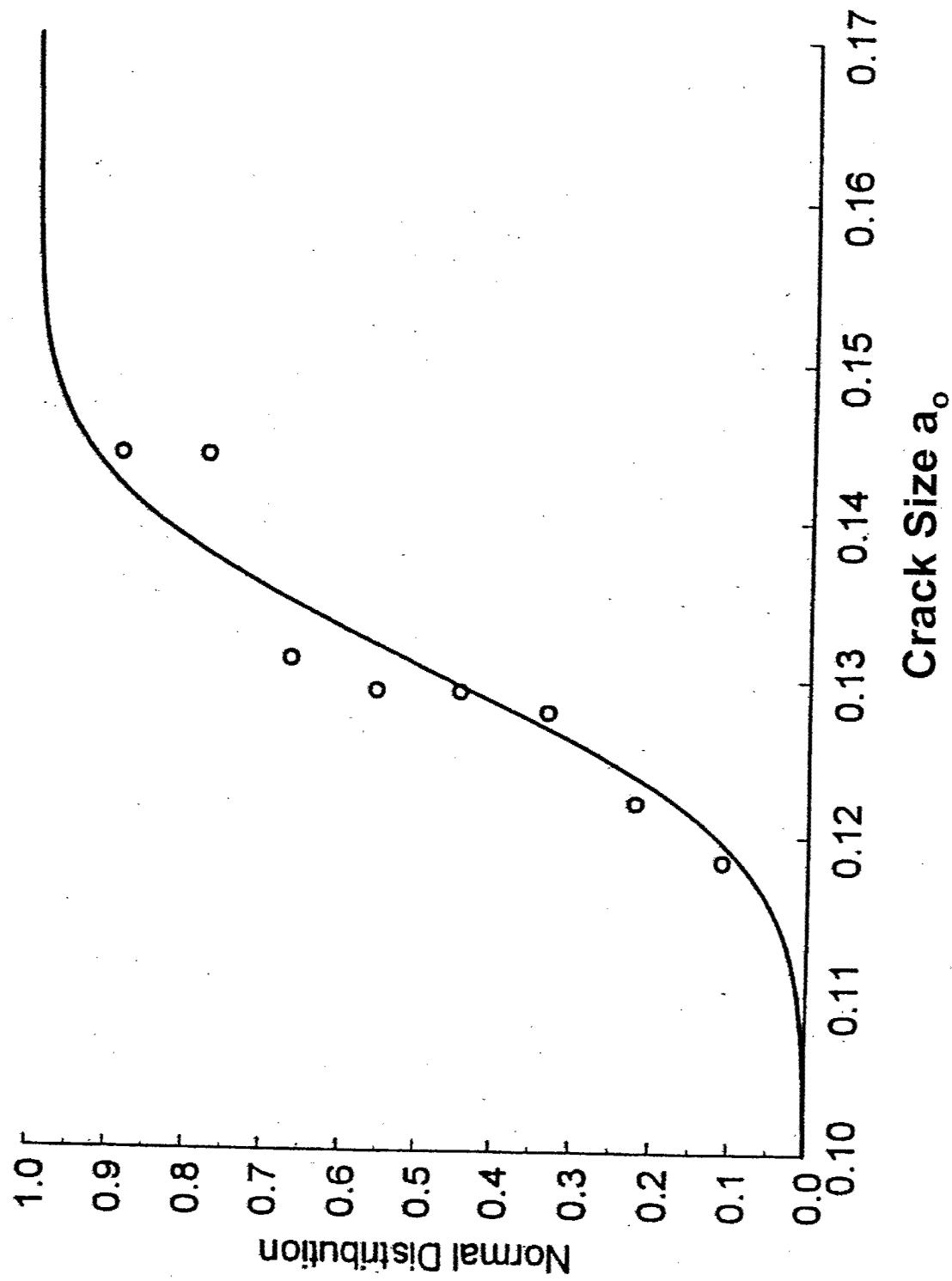
$$F_X(x) = \exp\left[-(x/\nu)^{-\kappa}\right]$$

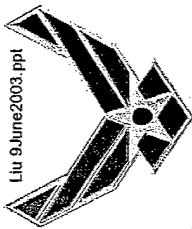
Second Asymptotic Distribution of Maximum value

$$F_X^*(x) = 1 - F_X(x)$$

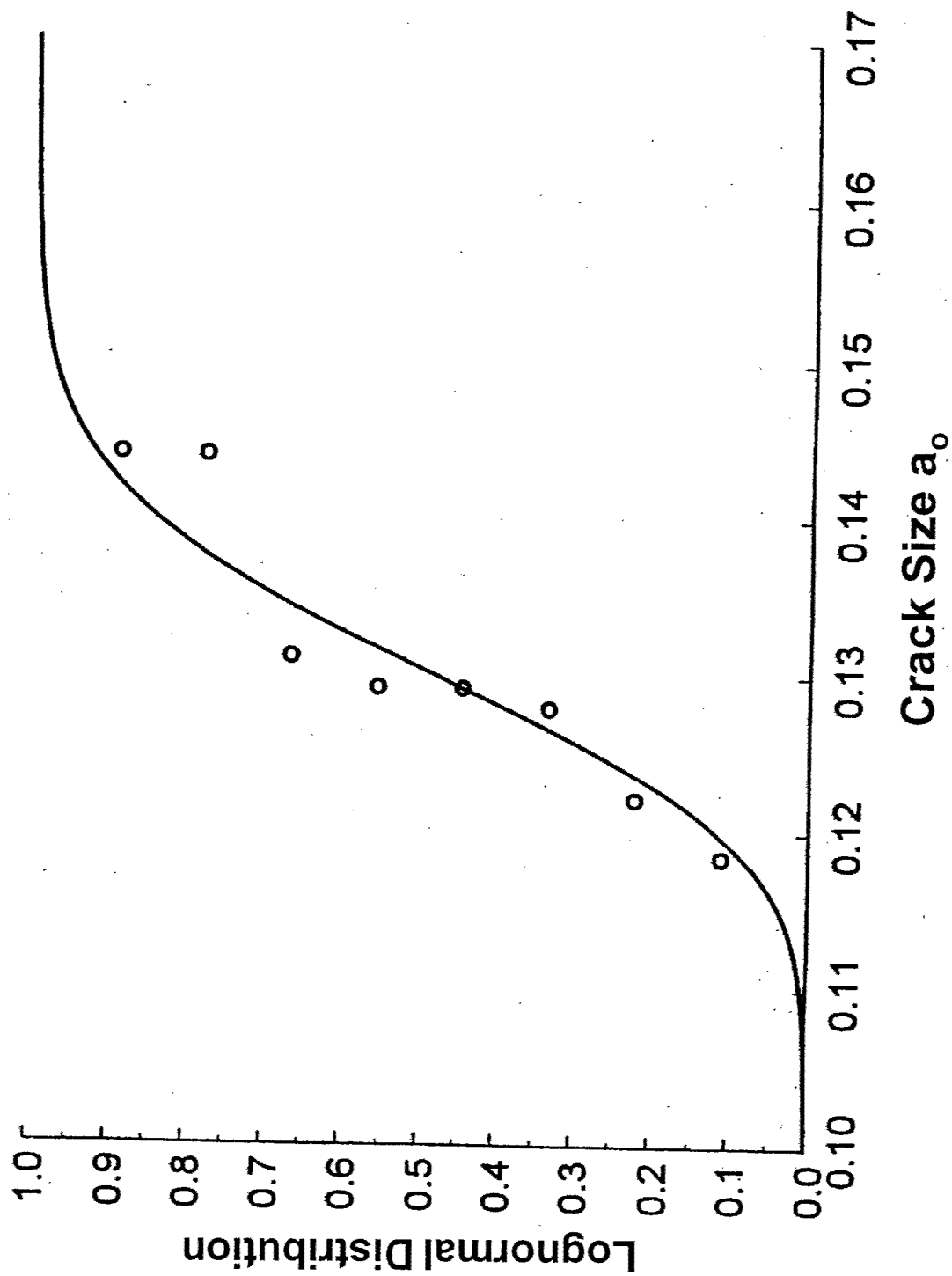
Exceedance Curve.

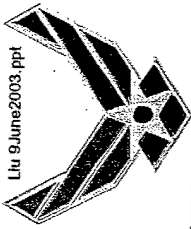
Normal Distribution Plot for a_o





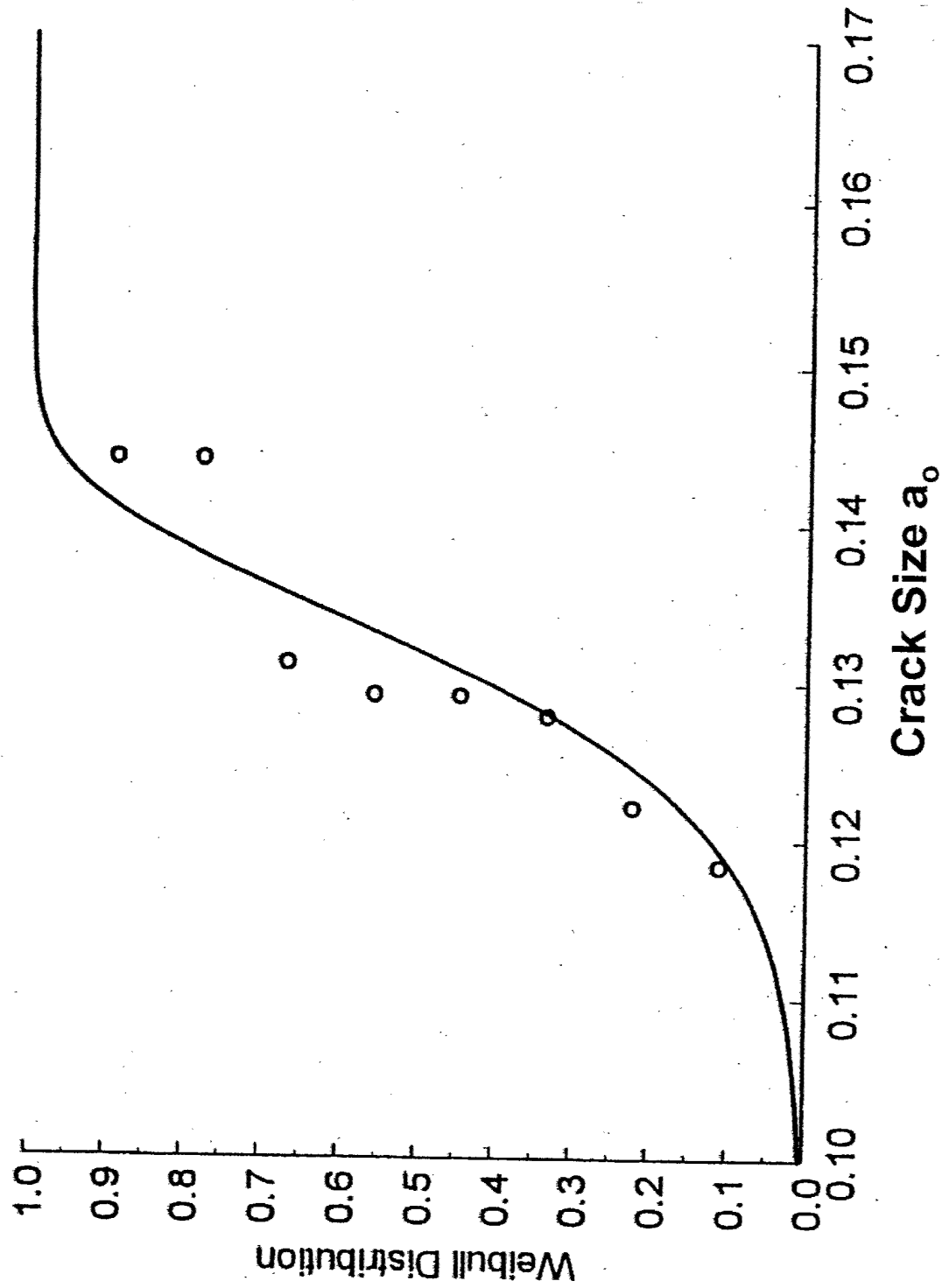
Lognormal Distribution Plot for a_o

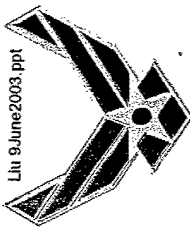




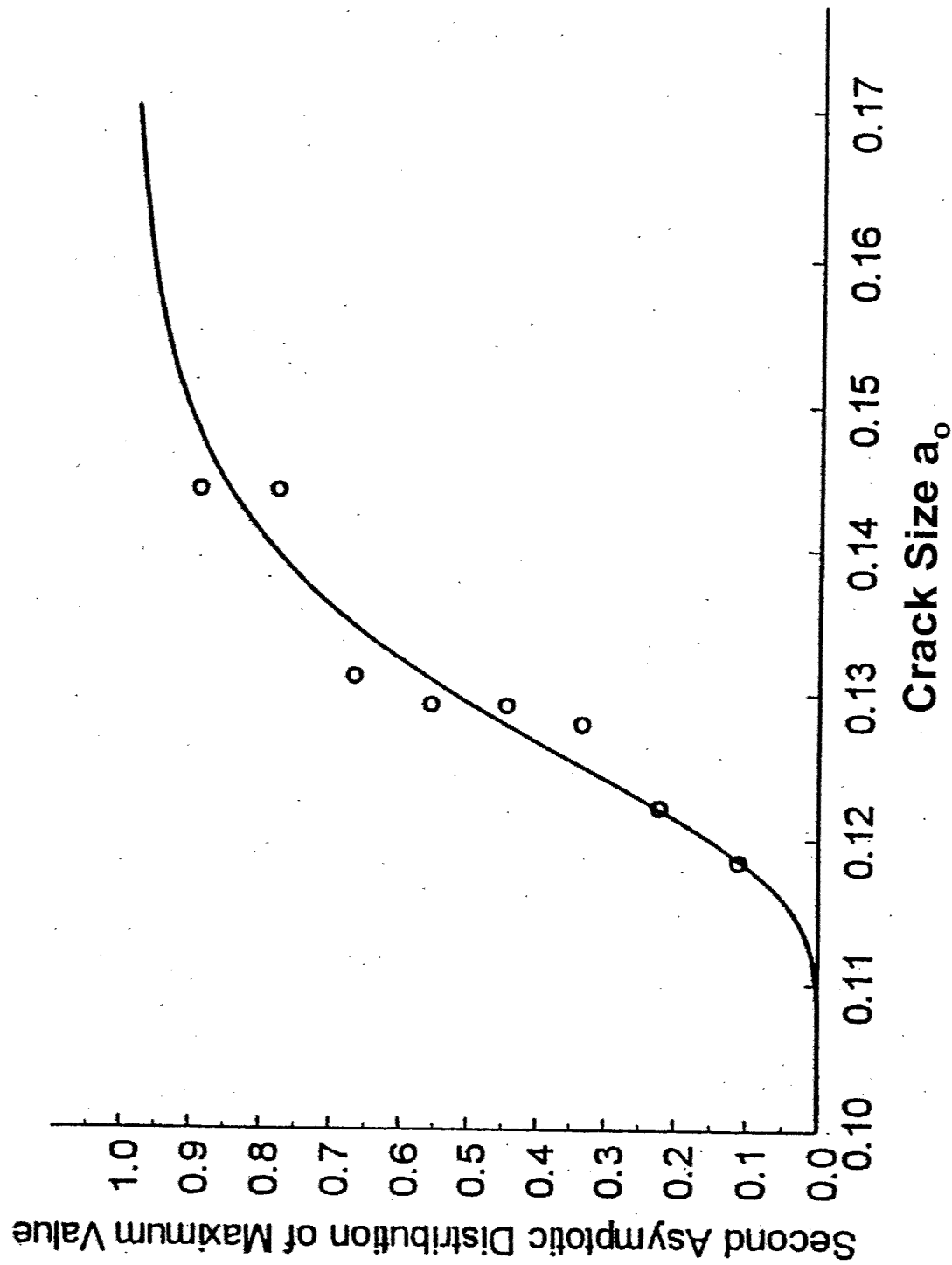
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Weibull Distribution Plot for a_0

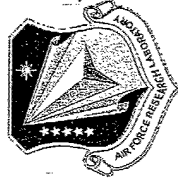




Second Asymptotic Distribution Plot for a_o



Distribution Parameters for Normal, Lognormal, Weibull and Asymptotic Distributions



Strain Rate = 0.04 min⁻¹

	a_0	a^*	a_c
u	0.1308	0.1344	0.1462
σ	0.0092	0.0090	0.0079
u^*	-2.037	-2.0092	-1.9242
σ^*	0.07021	0.06692	0.053961
α	17.5546	18.4513	23.0450
β	0.1348	0.1383	0.1497
k	13.2524	13.8081	17.1205
ν	0.1258	0.1295	0.1419

Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions



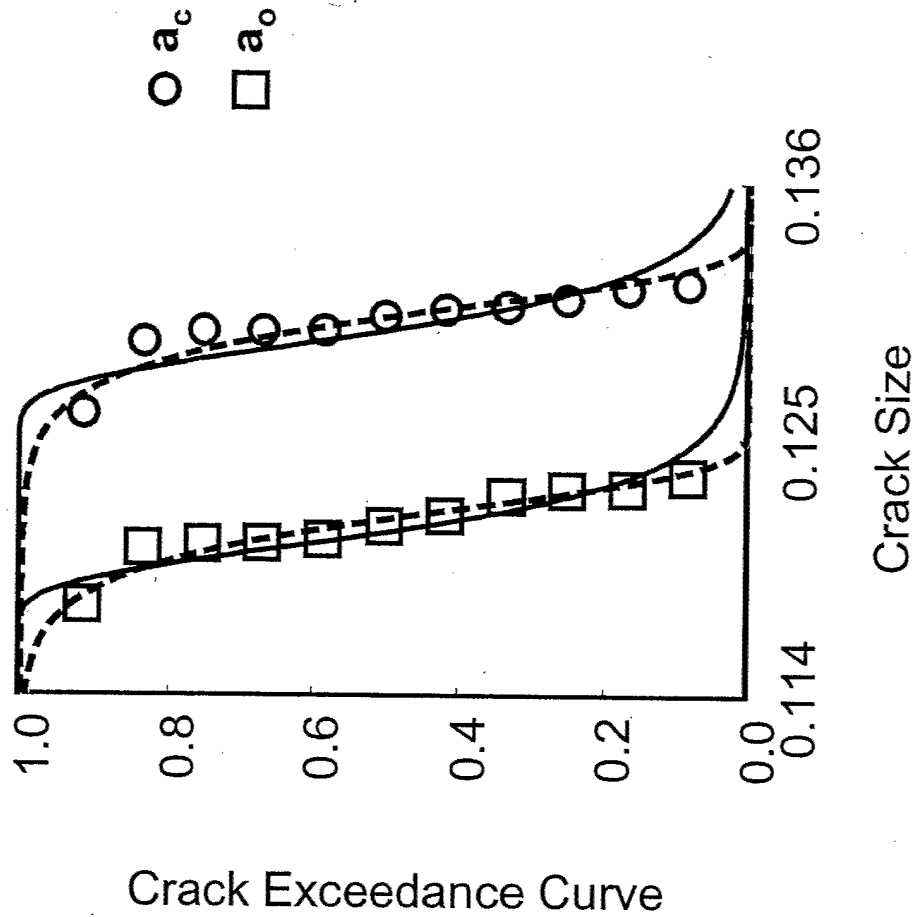
Strain Rate = 0.727 min. ⁻¹			
Parameters	a_c	a^*	a_0
μ	0.12999	0.12131	0.11865
σ	0.00152	0.00159	0.00157
μ^*	-2.04037	-2.10951	-2.13163
σ^*	0.01172	0.01315	0.01324
α	80.1416	74.4660	74.4279
β	0.1308	0.1221	0.1194
κ	72.4100	70.8130	71.9883
ν	0.1291	0.1204	0.1178

Distribution Parameters for Normal, Lognormal, Weibull, and Asymptotic Distributions

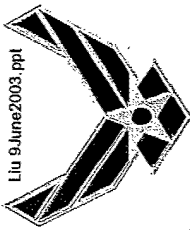


Strain Rate = 18.182 min. ⁻¹			
Parameters	a_c	a^*	a_o
μ	0.15750	0.14735	0.14597
σ	0.00290	0.00296	0.00290
μ^*	-1.84847	-1.91517	-1.92456
σ^*	0.01842	0.02008	0.01989
α	53.6601	49.5994	50.0668
β	0.1590	0.1488	0.1474
κ	51.3708	47.7906	48.4144
ν	0.1559	0.1458	0.1444

Crack Exceedance Curves for Strain Rate = 0.727 min^{-1}

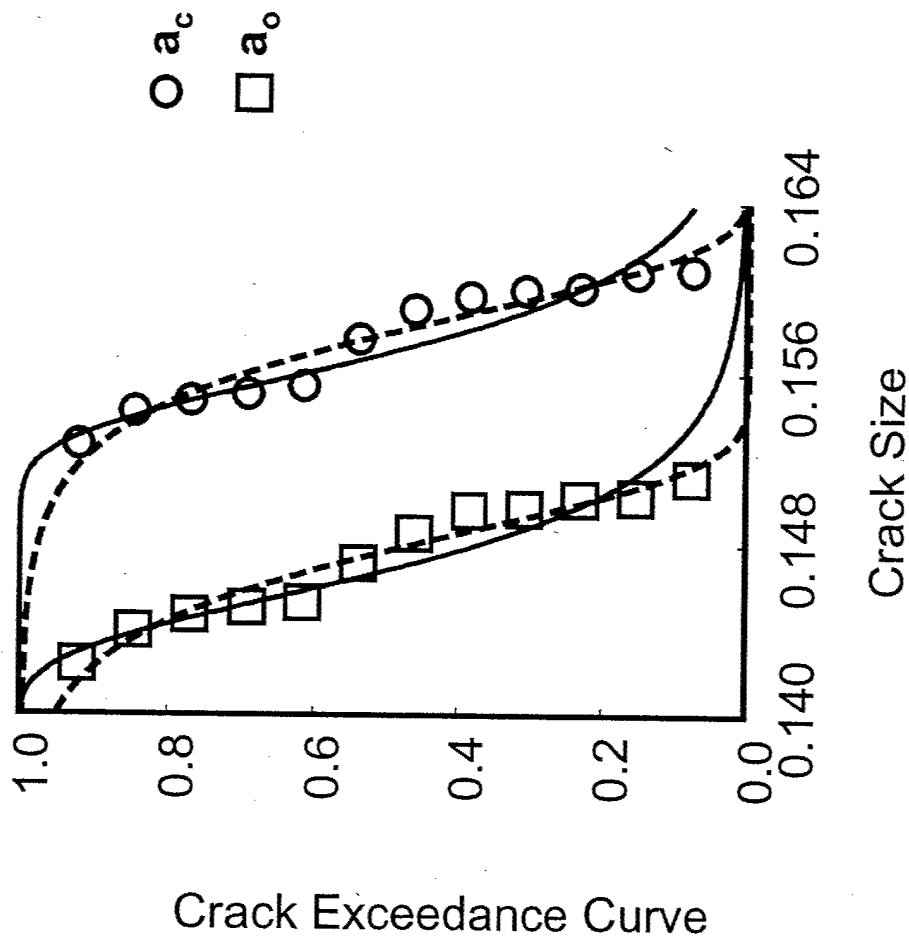


Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.



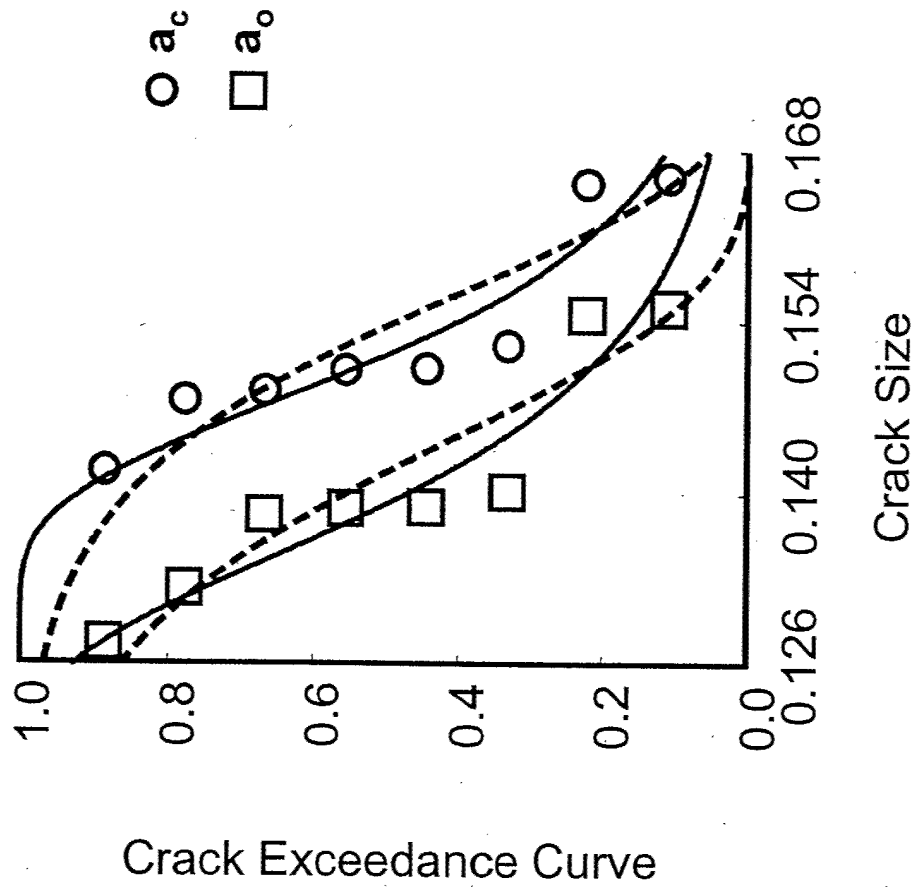
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Crack Exceedance Curves for Strain Rate = 18.182 min^{-1}

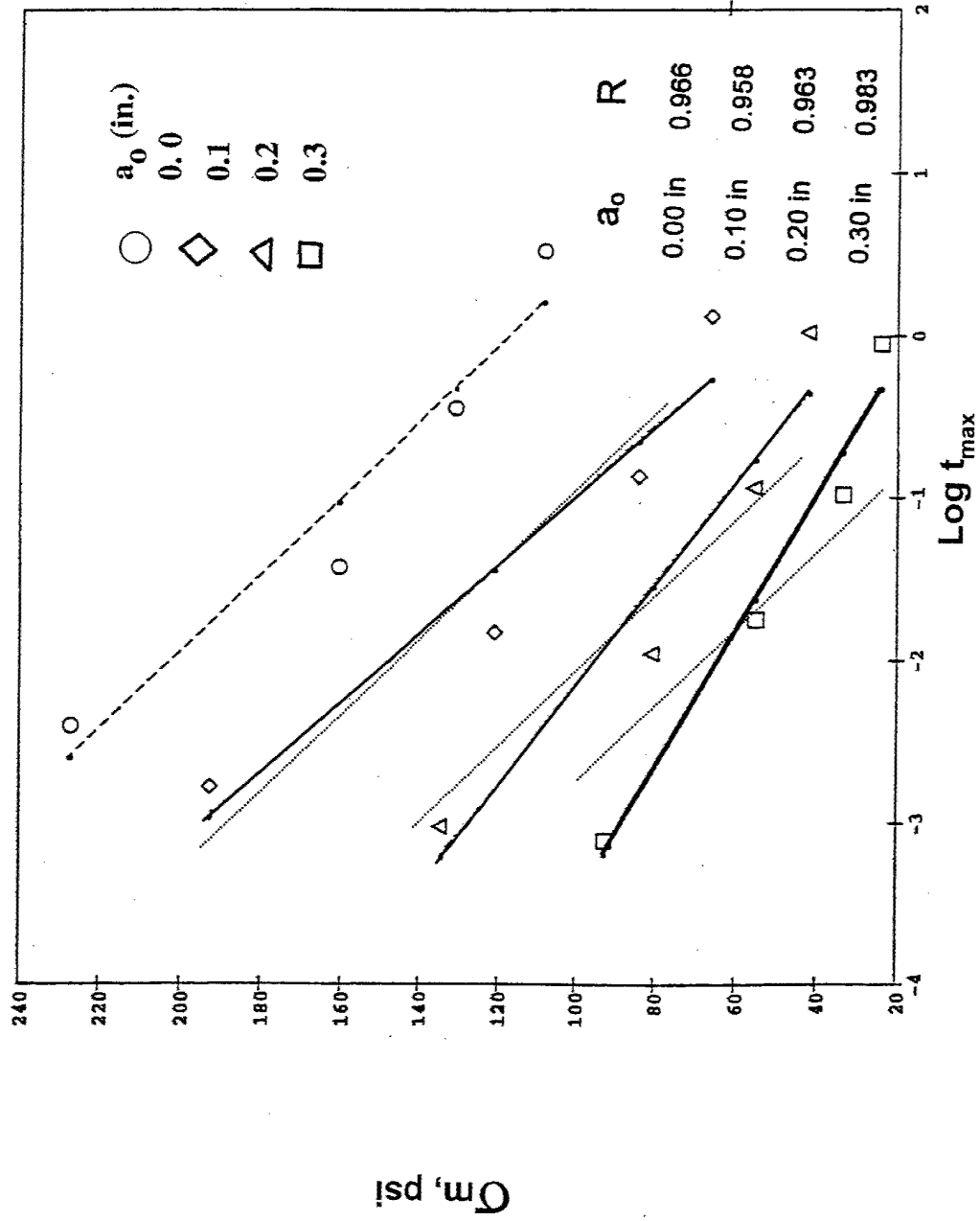
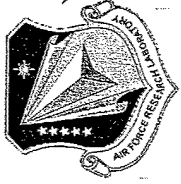
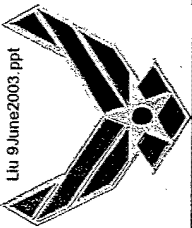


Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

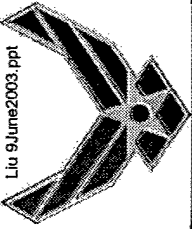
Crack Exceedance Curves for Strain Rate = 0.04min.⁻¹



Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.



Maximum Stress Vs Maximum Time



Conclusions:



- For the material studied, the estimate inherent critical crack size, a_o , is insensitive to the strain rate and the averaged value of a_o is 0.132 in., which compares well with experimental value.
- The inherent critical crack size follows the second asymptotic distribution of the maximum value.
- The estimated a_o should be used to develop the inspection criterion.